Adapt to Changes: Lessons from Two Irrigation Systems in Ezhou, China

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ABSTRACT
In this article I examine how local irrigation institution adapts itself to external intervention projects, like farmlands consolidation project in central China. Through a comparative analysis of two irrigation systems in Ezhou, a city located at Southeast Hubei, in the middle reaches of Yangtze River, I explain why one irrigation system can be better adapted to the intervention project, while the other failed to deal with the same one. Using the framework of robustness in Social-Ecological Systems, entities of two different irrigation systems are identified and their different outcomes are illustrated. Interviews with village heads, community leaders, and farmers make it possible for me to double check the case information and get to understand various incentives of different irrigation entities. Various incentives help me explain their behaviours in the institution adaptation processes. It turns out that the adaptive capacity of the Village Bao irrigation system is much higher, while the irrigation system of Upper Horse Village deteriorating still after the project. A key issue presented here is that interactions between water users and irrigation infrastructure providers, is important for robustness of local irrigation systems. Water users' engagement in institutional design may make a sustainable, robust and adaptive SES.

KEYWORDS
robust, adaptability, infrastructure providers, participation

INTRODUCTION

Irrigation systems, is a typical kind of complex social-ecological systems (SESs) (Lam 2006; Ostrom 2007). As a complex SES, it has four subsystems: a resource system (irrigation systems), resource units (water for irrigation), water users (farmers), and governance systems (organizations and rules that govern irrigation) (Ostrom 2007). These four components are relatively separable, but also interact with each other. Besides the internal interactions, according to Janssen and Anderies (2007), all SESs including irrigation systems, are "subject to a wide variety of perturbations to the governance systems, the resource users themselves, and to the underlying ecological system that constitutes the resource".

As for local irrigation systems, one of the most common external perturbations is different forms of intervention projects, initiated by local governments and international donor agencies. These intervention projects mostly are aimed at improving local irrigation governance, increasing agricultural productivity or water

equity, with considerable technical support and capital input. Still, some of them have not been successful despite their sincere efforts (Ostrom et al. 2002; Sengupta 2005; Gibson et al. 2005). Exploring the reasons of failure cases, scholars are accustomed to find solutions inside independent subsystems (i.e. resource users system, governance system or resource system), like "bad" water community with low social capital, inappropriate governance systems, water scarcity and etc.(Anderies, Janssen, and Ostrom 2004; Khwaja 2009; De Moor 2010).

Related to governance system, Sengupta (2005) summarized that there are three failure reasons: lack of political commitment, leadership vacuum, and no participation of stakeholder. However, these variables are general and superficial. They do not provide any guidelines for practical solutions. Besides, surveys of community-maintained infrastructure projects in Northern Pakistan from Khwaja (2009), showed that social fragmentation, and lack of leadership in the community do have adverse consequences on the upkeep of irrigation infrastructures, but their negative effects can be mitigated by appropriate project design. Hence, emphasizing project design may be more feasible and have better success in project implementation.

Talking about the governance system of SESs also, World Bank blamed the failure of some intervention projects on local governments' disordered focus. Local governments are accused of paying too much attention to build new facilities, rather than use the existing ones, and "roles for project planning, implementation, cost recovery, operations and maintenance (O&M), and asset ownership are poorly defined and communicated". The report pointed out that, "although communities are usually expected to provide a share of costs (mainly through in-kind contributions), it is often unclear how the level of contribution has been determined or how the level relates to demand". In this situation, if the intervention projects only provide technical and financial support during construction; and after construction, each organization's role ends and only the community is assumed to take up the responsible for maintenance without any pre-interactions with infrastructure providers, local resources would keep on deteriorating after the project (Khwaja 2009).

Related to resource users system of SESs, some scholars asserted that inappropriate project designs, which ignoring local existing institutions or social capital, shall impair the SESs' resilience (Trawick 2003; Bebbington et al. 2006; Skjølsvold Moe 2010). They may not help improve local irrigation management, even they can make the current situations worse off. One compelling argument has been put forth by Ostrom and Gardner (1993). They argued that the construction of extensive infrastructure facilities, like a permanent headworks, without requiring that capital investment be paid back by local farmers, has two adverse consequences. Firstly, it may destroy existing social relationships embedded in the community, and reduce "the recognition of mutual dependencies and patterns of reciprocity between headenders and tailenders that have long sustained the system". Secondly, it will give

disincentives to farmers and government officers who were engaged in collective irrigation activities. “Without a realistic requirement to pay back capital investments, farmers and host government officials are motivated to invest in rent-seeking activities instead”. The argument was supported by Lam’s empirical study of over 100 irrigation systems in Nepal (1998). He found that cropping intensity and agricultural yield of irrigation systems with rude headworks, like mud, rock, timbers, are significantly higher than irrigation systems with permanent headworks, built with concrete or iron materials.

Taken together, from the irrigation literature, I found that not all intervention projects success in practice. Partially, it is due to failures in subsystems. Yet it is not the whole picture of the SESs. According to Lam (2006), “a well-performed irrigation system is characterized not only by a well-maintained infrastructure, but more importantly a productive working order of farmers (as resource users) and irrigation managers (as infrastructure providers)”. However, different interaction behaviours between water users and infrastructure providers are rarely considered in previous research.

In this article, rather than just analyzing the resource users, or governance systems solely, I will concentrate on the interactions of different irrigation entities. Taking irrigation systems as an instance, the interdependent relationships between water users and infrastructure providers shall be highlighted, in the process of mediating through interactions with local water resources and irrigation infrastructures (Anderies, Janssen, and Ostrom 2004; Shivakoti and Bastakoti 2006). The article will explore how farmers and infrastructure providers interact with each other in a transitional country, in face of an intervention project, and accordingly how they respond to the external changes in practice?

This article uses the framework of robustness in SESs, to explain why two most similar cases facing the same intervention project- the farmlands consolidation project, have different outcomes. Both irrigation systems are located at Ezhou, a city located at Southeast Hubei, in the middle reaches of Yangtze River. They have similar water conditions, similar size of water users, and governance systems. However, different project designs make a different at the interactions, and in turn lead to different outcomes. On the bases of a brief introduction of irrigation governance systems in China and the farmland consolidation project in Ezhou, I will scrutinize the cases respectively. Irrigation entities of two systems would be identified, and their interactions would be illustrated. Finally, I offer some recommendations and conclude.

THE FRAMEWORK

Before embarking on the journey to decompose the cases and address the research question, I need to clarify my use of the framework, and the methods to collect data. In irrigation literature, there has been a considerable body of theories, talking about under what conditions commoners would cooperate with each other to improve

existing irrigation situations (Ostrom, Gardner, and Walker 1994; Bardhan 2000; Meinzen-Dick, Raju, and Gulati 2002; Araral Jr 2009). These discussions mainly focused on water users' incentives and their behaviour, given that irrigation institutions and related infrastructures are in place, and the resource base is static. However, one of the issues that has always been overlooked, is that water is a fluid and dynamic resource (Shivakoti and Bastakoti 2006). The nature of the water is not static; any changes to irrigation infrastructures and the farmlands it irrigate would have significant impacts on the resource base. Since all SESs are potentially vulnerable to new disturbances in their environment, they cannot be robust to all (Janssen, Anderies, and Ostrom 2007). Herein, the process of adapting deserves an insight.

Another issue that also has been given little attention is, water users are not always tantamount to infrastructural providers. Although in some cases, farmers do operate and maintain the irrigation systems by themselves, like desilting, weeding, and stopping encroachments on tank beds (Dayton-Johnson 2000; Bardhan 2000). Still, in many cases, the fact is that the irrigation engineers are more bound to the design of operation and maintenance issues of irrigation systems[1]; and independent contractors are chosen based on a bidding system to implement the plan and provide irrigation infrastructures (Reidinger 1974; Ostrom 1999). Hence, in situations that the resource users and infrastructural providers are different, how the two entities interact with each other shall be explored further.

In this article, I intend to use the framework of robustness in SESs as a practical-analytical tool. Anderies and some other scholars (2004) addressed, answering questions like what makes SESs robust, why some SESs can deal with external disturbances while others failed, shall look at the institutional configurations that affect the interactions among resource, resource users, public infrastructure providers, and public infrastructures. According to Anderies et al. (2004) and Janssen et al. (2007), the important point is to recognize the linkages between the resource users and governance structures. Put another way, the interactions between water users and public infrastructure providers through their links with water resources and engineering infrastructures have an effect at the robustness of irrigation systems.

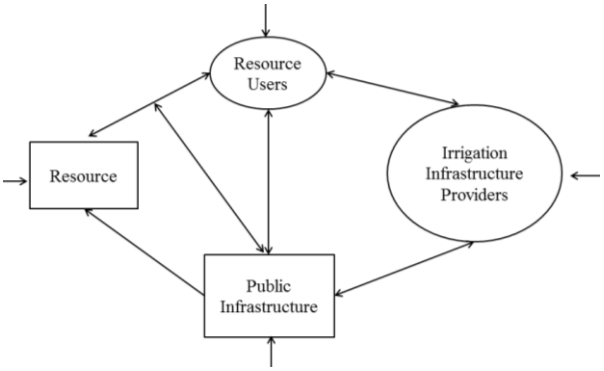

Figure 1: The general framework of Anderies et al. (2004).

[1] They are supposed to follow a predetermined irrigation plan issued from their supervisors.

METHODS

In this article, I adopt a comparative case study approach to implement the research. For one thing, inasmuch as irrigation systems are complex SESs, and my focus rests on interactions of components of SESs, I prefer to use case study methods. As Verschuren (2003) demonstrated, case study is in an advantageous position at analyzing an in-depth holistic story, compared to survey which needs to split research units. For the other, to resolve the "many variables, small N" problems, I purposively select two comparable cases in Ezhou's context. Both cases exemplify two different interaction patterns between water users and public infrastructure providers, in the face of external intervention projects in contemporary rural China. To ensure comparability, most-similar strategy is used here[2]. Both irrigation systems are located at Ezhou, a city located at Southeast Hubei, in the middle reaches of Yangtze River. They have similar water conditions, similar size of water users, and governance systems. Holding these variables constant, I can concentrate examining the causation relationships between interactions of water users and infrastructure providers and the adaptation outcomes.

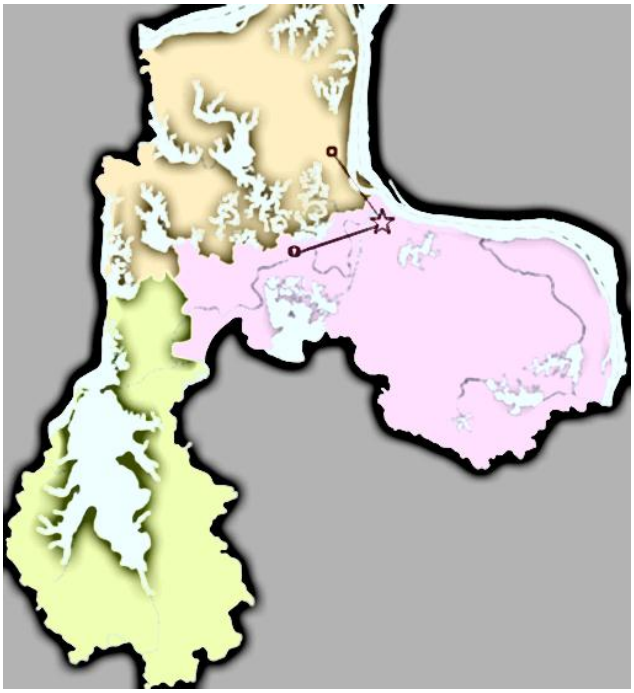

Figure 2: Locations of BVIS and UVIS
(The above point indicates Irrigation System of Bao Village; the low point indicates Irrigation System of Upper Horse Village; the five-point star indicates the city center of Ezhou)

This study used both primary and secondary data for studying the institutional change of the two irrigation systems given the introduction of the farmlands consolidation

[2] According to Lijphart (1971), "comparable" means: similar in a large number of important characteristics (variables) which one wants to treat as constants, but dissimilar as far as those variables are concerned which one wants to relate to each other. That is to say, cases should be as similar as possible except for the independent and dependent variables.

project. The secondary information was mainly drawn from records of the local Irrigation Stations and Ezhou Yearbook (1991-2011). The primary information was collected from a series of semi-structured, in-depth qualitative interviews conducted from June 1st to June 25th, 2012. The respondents were chosen from the population of resource users and public infrastructure providers in the two irrigation systems, and in the end amounted to around 10 interviews in both cases, 20 altogether. Each face-to-face interview takes approximately 1.5-2 hours. Interviews with village heads, community leaders, and farmers make it possible for me to double check the case information and get to understand various incentives of different irrigation entities. In addition to formal interviews, I also walked through both the irrigation systems, did some direct observations at infrastructure conditions, and the situations of alternative water resources.

IRRIGATION GOVERNANCE IN RURAL CHINA SINCE 1978: AN OVERVIEW

Since the economic reform in 1978 in China, Chinese individual farmers have been given significantly increased decision-making powers over the use of their own resources, including irrigation water resources. Inasmuch as the reform, farmlands were allocated to village households according to their family size, which resulted in land fragmentation. Because of the character, irrigation communities (composed of field neighbors) are tantamount to village communities (composed of residential neighbors) in the context of rural China. Hence, in this study I shall take irrigation system of a village as the unit of analysis. This is accordant with the fact that in China village is the basic unit of local irrigation governance, and also be consistent with existing common-pool resources research for further comparatives (Hunt 1989).

Accompanying with the dismantling of the commune system, cultivation lands were farmd on a household basis under a contract system. According to the study of Nickum (2005), the subsequent semi-privatization reform and, the chaos of system transition then, made irrigation governance in a tight spot: ponds were filled, control structures were absent, canals and drains intermingled and irrigation infrastructures were looted by some unruly villagers based on their solely consideration of their own interests[3].

Due to aging and prolonged neglect, many irrigation infrastructures started worn out, and irrigation systems deteriorated rapidly. A survey, conducted by the Ministry of Water Resources at the beginning of the 1990s, showed that 40 percent of the structures in the canal systems of 195 large irrigation districts functioning poorly. To restrain the negative trend and limited by financial budget at that period[4], Chinese

[3] These unruly behaviours came out for a variety reasons: some villagers want to build a house above the canal, so they simply filled the canal; or some villagers want to cultivate more lands, they may occupy the pond area for themselves; or they simply stole engine pump machines and exchanged them for money in black market. Nonetheless, these behaviours mostly were self-interest, ignoring common benefits.

[4] One of the major factors driving water policy reform in China, as elsewhere in the world, is the budget problem (Nickum 2010). On one hand, local governments were short of money to build or repair irrigation systems. As estimated, Chinese county governments had accumulated 220 trillion yuan in debt, by the end of 2000. Among

government turned to international agencies for help. Inasmuch as the situation, external donor agencies (i.e. World Bank) have initiated many irrigation intervention projects and series of water reforms in China since 1990s.

Thereafter, new forms of water management emerged in rural community of China. Research results showed that since 1990, especially after 1995, collective management has been incrementally replaced by water user associations (WUAs) or contracting regime (Hussain 2007). The governance structure of WUA managed irrigation systems is built upon "participatory irrigation management" guidelines, emphasizing community participation and farmers' self-governance approaches. Meanwhile, "contracting" is a system in which a general investigation of all-level canals and installations shall be needed for preliminarily calculation, and items like contractor's requirement, contract forms, duration, responsibilities, rewards and punishment be decided later between the village and individual contractors[5]. In general, there were two new regimes of water management. Still, there were a variety of mixed combinations in institutional forms in practice, given that the central government allowed local governments considerable room in making their own decisions on the exact form and timing of institutional changes (Skjølsvold Moe 2010).

Sequentially, in 2004, the central government initiated a large-scale tax reform around the country. It cut down different kinds of tax and charges at rural areas, and also cancelled the voluntary and common labor work. These regimes usually were utilized by governments in the Commune Period to motivate local labors or organize farmers to participate in irrigation operation and maintenance work. And now they were all dismissed when the tax reform finished, which makes the incentive mechanisms absent hereby.

Nowadays, Chinese governments would rather influence rural areas through a variety of intervention projects. Like in this study, the project - farmlands consolidation -invests a lot of money to selective villages to level their farmlands, line the canals, and renovate local pump stations. These projects usually are contracted out to small contractors, not limited to local villagers. The engineering planning tasks are transferred to local irrigation planning research centers, which are still subject to local water resources bureaus.

In summary, the construction and management of irrigation infrastructures at present are mainly provided by government and individual contractors, rather than village communities. It is necessary to examine how local irrigation institution adapted itself to a series of institutional changes and sustained. Base on the framework of robustness

them, 35.6% counties had a deficit (Su 2006). On the other hand, water projects, especially irrigation, are rarely profitable. In this situation, external donor agencies have assisted with many of irrigation system construction works, while adding some fiscal discipline in the form of an obligation to repay.

[5] Infrastructure projects have come to rely heavily on subcontracting and competitive procurement in recent decades.

in SESs, I posit that the linkage between resource users and public infrastructure providers is a key variable affecting the robustness of local irrigation systems.

THE FARMLANDS CONSOLIDATION PROJECT

In 1988, the Chinese government launched an agricultural comprehensive development (ACD) program.[6] The coverage of the program included land consolidation and investment for diversified economic development (Wu, Liu, and Davis 2005). In particular, the main investment (more than 60%) was put on land consolidation, and its share in total ACD investment was increased steadily in recent decades. Farmlands consolidation project is the act of a) expanding the irrigated area and improving plot and irrigation and drainage conditions; b) improving farm plot configuration, including the plot size, shape, and layout, through a suitable merging of smaller and irregular-shaped plots into larger ones of a regular size and shape; c) improving farm road systems to provide better access to plots for both workers and machinery; d) reducing fragmentation of a farmer's land into many small, noncontiguous plots scattered in many locations, according to the goal and usage defined by land use planning, as to improve farming bases.

As a dominant subproject of ACD program, the farmlands consolidation project was managed by the ACD office set up at all government levels. At the county level, the ACD office was in charge of the formulation of farmlands consolidation plans and initial selection, application, implementation and appraisal. Normally, local irrigation systems would be ranked by the county ACD office according to some selection criteria (i.e. production potential, cost-effectiveness, farmers' willingness to participate, income distribution, and ect.), then those priority villages be invited to submit proposals to compete for their names appearing on the final list. In the end, project villages can have government grants, which cover part of the costs, while the rest costs would be collected from villagers, in the form of labour inputs.

Normally, detailed project design has been in the hands of engineers from local irrigation planning research centers, which are subject to local water resources bureaus. And relevant information will be included in the submitted proposals and ACD offices' implementation documents. However, when scholars tried to understand the impact of the intervention project in the case of China, they always found that sound evaluations are usually scarce (Wu, Liu, and Davis 2005). For one thing, existing research works only explored performance differences between project villages and non-project villages, or compared performances of one village before and after the project implementation. This kind of simple direct comparisons may not adequately explain the diversified outcomes of intervention projects. For the other, data scarcity has been a practical issue in research about China (Tsai 2008). The data available from the ACD offices are quite narrow at engineering data, and project statistics, which limit the scale of whole story to researchers. In short, this article shall present an in-depth comparative analysis over two irrigation systems, to explain why

[6] This section draws on Wu, Liu and Davis (2005).

one irrigation system can be better adapted to the intervention project, while the other failed to deal with the same one[7].

CASE STUDIES

In both cases, the same national project- farmlands consolidation -entered local village communities, lined most canals and repaired irrigation pump stations. Furthermore, both villages are plain areas with adequate water resources, the same climate conditions, the same distance from the city center; both have similar group sizes, with identified team leaders, little socio-economic heterogeneity among the villagers, and no lineage groups. In general, these two irrigation systems, as two independent social-ecological systems (SESs), share many commons in physical attributes and community attributes. Still, they displayed different responses to the external project. Although both irrigation systems have persisted since they are established, their different responses to external changes illustrate the different extents to which they are robust.

Table 1: Entities in both irrigation systems.

	Irrigation System at Bao	**Irrigation System at Upper Horse**
Resource	Water source (River), irrigated area (370 mu)	Water source (River), irrigated area (500 mu)
Resource Users	Farmers of Bao Village, 93 households, 310 people,	Farmers of Upper Horse Village, 300 people
Public Infrastructure Providers	Government, Village collective	Government, Village collective, contractor
Public Infrastructure	Canals, plots of land, one engine pump station	Canals, plots of land, two engine pump stations, two ponds

Case 1: Irrigation System of Bao Village (BVIS)

1. The traditional irrigation system

The SES of the traditional BVIS is composed of the farmers and village collective, their physical environment, and their interactions. Village farmers are the resource users. They use water from Xue River to irrigate their farmlands. The irrigation system of Bao Village, was mainly built by farmers in the 1960s[8]. The pump station, which is still working nowadays, was established in 1975.

Bao Village now (year 2011) has 93 households, 310 people. The area was an uncultivated low-lying land at the beginning. Later, when the Fan Gate was

[7] To some extent, this case study can contribute to be a kind of independent assessment of the ACD program at present in China, and help to fill up the void in existing project reports.

[8] In the Commune period, the rural labour force was employed in rural public works, and rewarded by work points. At that time, during winter seasons, large numbers of rural people worked on construction and maintenance of irrigation or land-leveling projects.

established in the 1920s, this place is no longer subject to serious flood disasters, then farmers nearby gathered around and built a new village community here. The history can explain why there are 19 surnames in the village. There are no lineage groups in the Bao Village.

BVIS is a surface water irrigation system. The water of the village mainly comes from a nearby river -Xue River, which connects with Changjiang River through Fan Watergate. In the dry seasons, farmers pump water from the Changjiang River to Xue River; in the rainy seasons, excessive water will be drained to Changjiang River, and then flow into the sea. Since Xue River has the Changjiang River as the backup water resource, which is the longest river in Asia, and also one of the biggest rivers by discharge volume in the world, water in Xue River can be said abundant for villagers in Bao Village. To better utilize the water resources to service local agricultural activities, farmers of Bao Village built a 150-meter intake canal to divert water from the Xue River to the Bao Village.

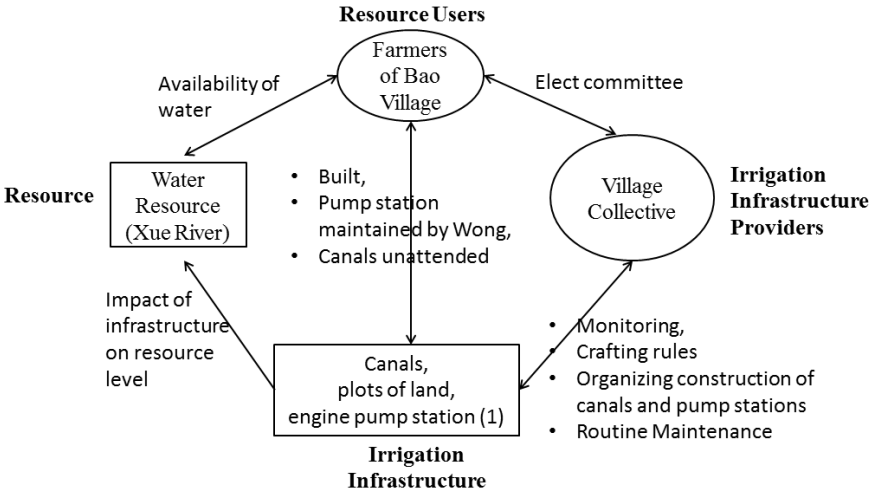

Figure 3: Application of the framework to the traditional BVIS.

The pump station was located by the side of intake canal. There were two electronic pump machines in the station: one is fifty-five KW, and the other is forty KW. The pump station is always a collective asset in the village. Now it is operated and maintained by a farmer named Wong, who resides in the village. However, in the commune period, there are a team of thirteen farmworkers who are in charge of the pump station. Since the Household Responsibility System was established in 1980s, small landholders' benefits are prioritized. Thereafter, the number of collective farmworkers decreased dramatically, like the pump station in Bao Village, the number of workers has been significantly reduced from thirteen to one from 1982. Moreover, originally there are two water guards in the village, in charge of monitoring irrigation water flows, open/ shut water gates of each field. After the Reform in 1982, water guards were dismissed because the village collective was short of money to hire any. From then on, farmers were responsible for watering their own fields, instead of cooperating with each other. There was no maintenance works organized, in this

semi-privatization context. As a result, local irrigation system began to deteriorate without appropriate attention. Although ponds and pump stations still belong to village collective, village leaders find it hard to organize farmers to work together, especially they find little rewards could be paid back to villagers.

2. Changes after the project introduced

When rural community was intruded incrementally by market forces, individual water users' incentives to engage in collective action for public works have been offset sharply by higher wages in manufacturing industry, and uncertainties of benefits from maintenance works. In particular, in 2004 the tax reform cut off all charges and labour responsibilities for farmers, which making them much less likely to volunteer any irrigation works.

However, in 2010, when the farmlands consolidation project was introduced into the Bao Village, things changed. Like many government irrigation projects, the design works were designated to Ezhou Investigation and Design Institute of Water Conservancy. Uniquely, as to the project in Bao Village, the design works were negotiated between the farmers and the design institute.

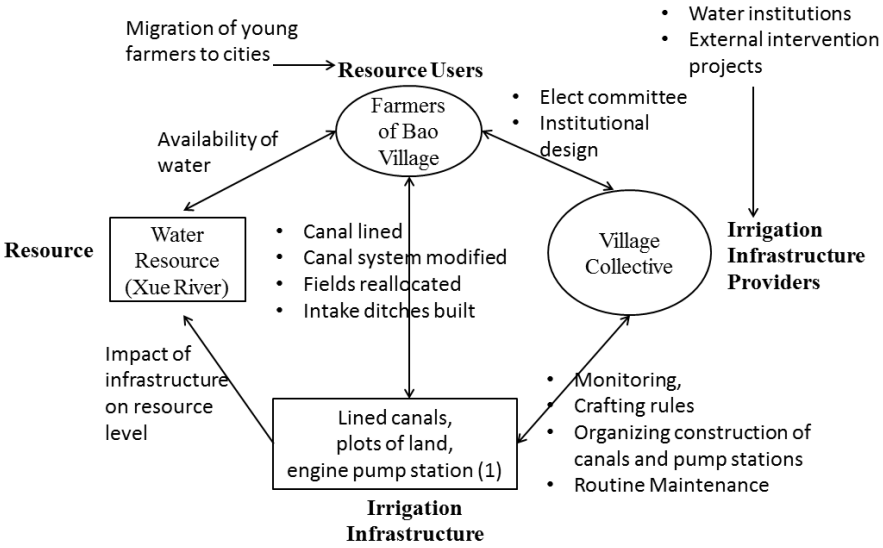

Figure 4: Application of the framework to the current situation of BVIS after the project being introduced.

Farmers of BVIS make three main changes to original design. Firstly, they modified the draft leveling and canal system diagram to make it more adapted to local needs. They found that there were some designs impractical in fields according to local farmers cultivating customs. To save unnecessary input in these useless lines, they changed the routes of two canals in detail.

Secondly, they reallocated fields accompanying with the implementation of farmlands consolidation project[9]. All fields of BVIS were categorized into five groups. Then

[9] The Bao Village has coordinated their land plots three times since the Reform in 1982: the first coordination is in

ninety-three households were assigned in equal pieces to each field group (that means in general averagely eighteen households for each field group). Also, the number of people was matched up to these five field groups (that counted to sixty-two people for each field group; in some situation, if there are some big families with many people, they can occupy a category with three households[10]). Then each field group elected a team coordinator to be in charge of making draws. And all households involved (in the field group) drew lots to get a configuration of fields for themselves[11]. Because the farmlands consolidation project has leveled all the grounds of BVIS, which at utmost reduces variations of irrigation conditions among fields, households finally held fields with similar irrigation conditions. Given the elaborate modifications of original institutional arrangement, the project makes sure that no irrigators in the system were consistently disadvantaged in the allocation of water.

Thirdly, they redesigned the field structure and built intake ditches for each field. Before the farmlands consolidation project, some fields have to share intake ditches to irrigate their lands. In this situation, the field without the intake has to negotiate with the above field which has the intake to arrange its irrigation schedule. Otherwise, there is a possibility that they (fields downwards) wash away fertilizers from above, and initiate a quarrel with the farmer above. With the new design, at present each field has its own intake ditch. This largely reduces the conflicts over water issue among farmers.

Nonetheless, the new scheme of BVIS seems run well at the present stage. In the design process, villagers of Bao gathered together to measure the length of unlined canals, and redesigned the map of fields. Each household sent a representative to speak for their own benefits, and then village leaders collected these suggestions, transferred them to engineers to make it true. Moreover, local farmers were hired in the construction works. They were paid fifty - sixty yuan per day. The involvement of resource user in design process, and their interactions with infrastructural providers reflected timely need of farmers in face of challenges[12] from market forces. This makes BVIS robust for the time.

Case 2: Irrigation System of Upper Horse Village (UVIS)

1. The traditional irrigation system

The SES of the traditional UVIS is composed of the farmers, the village collective,

the year 1997, the second happened in 2003, and the last and the latest was in 2011.

[10] In this way, the gains and losses of benefits in the process of agricultural production may be more easily balanced inside one family. For other categories with small families, they can be guaranteed to compete in a fair way inside the group, for they have little economic heterogeneity with similar areas of fields.

[11] Normally, each household would have a configuration of fields, which both have parcels near the source of water and parcels distant from it. This makes every water user be the headenders and tailenders at the same time. In this way, they are expected to have the same incentives to engage in irrigation activities.

[12] These challenges included, that young generation of village community has been absorbed into manufacture industry, that has created acute labour shortages for public works like irrigation activities, and weaken knowledge base about how to operate or maintain local irrigation systems; and more stressful competition with other water consuming sectors, especially those industrial water users (Shivakoti and Bastakoti 2006; Lam and Ostrom 2010).

their physical environment, and their interactions. Village farmers were just the resource users at the beginning, and later a few of them became irrigation infrastructure providers after they were given a contract for irrigation facilities, like pump stations.

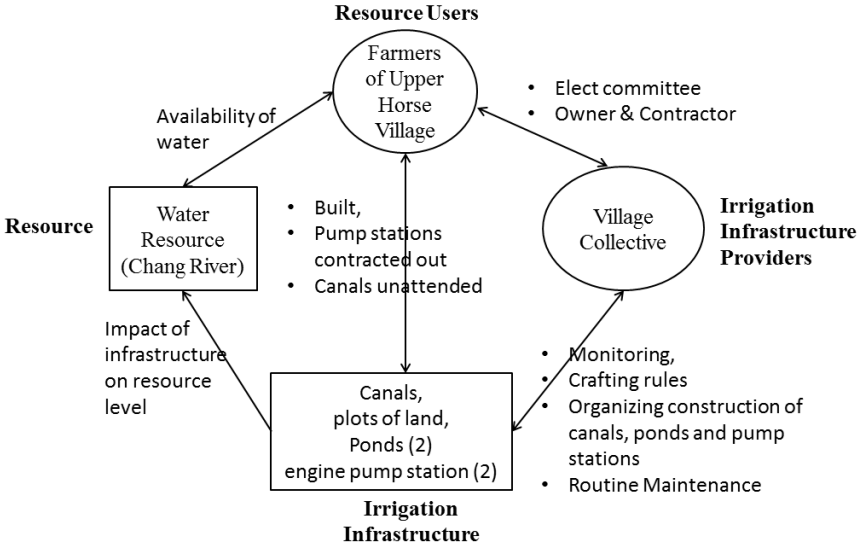

Figure 5: Application of the framework to the traditional UVIS.

UVIS is also a surface water irrigation system. Upper Horse Village has two water courses that can cover all fields. One is the Seven-Zero Channel, and the other is the Pilin Channel. Both water courses compose an L shape, and Pilin Channel connects Chang River at its end[13]. Chang River brings abundant water resources to the village. In particular, Pilin Channel was built in 1960s, and the other (Seven-Zero Channel) was built in 1970s by local farmers. In earlier times, both channels were cleaned in winter seasons by farmers themselves. After 2004, the cleaning works were contracted out to local farmers who owned a dredge based on a competitive bidding system. Moreover, farmers of Upper Horse Village built two pump stations and operated two ponds to store water for dry seasons. From the late 1990s, the pump stations have been contracted out to local farmers for water management. And contractors keep changing for a series of reasons[14]. In 2009, a villager named Ma just took over both pump stations. Still, ponds belong to the village collective.

Unlike the case of BVIS, after the Reform in 1982, water guards have been kept in UVIS for a period until 1990s, because the village collective had enough budgets then. Water guards were experienced elderly farmers. They were authorized to control all water gates according to rice heights and water heights in the field. They were paid

[13] Chang River is an inland river located at western Ezhou. It flows from the Changjiang River 45 km south to the Liangzi Lake.

[14] In late 1990s, the State Council of Chinese government issued a policy about revitalizing village collective assets. Thereafter, many assets, once belonged to village, like mountains, ponds, pump stations, and even some village enterprises were contracted out to individuals. These contracts have durations. Once they become due, always village leaders will find another contractor to replace the original one, if the last contractor would not like to renew the contract. The reasons of not renewing can be various. One possibility is that contractors found little profits gained from the deal; but also, it may relate to private issues, like short of money etc..

ten yuan per mu based on irrigation area in their care. However, they were still dismissed when the village collective budget got worse in the late 1990s. From then on, local farmers began to irrigate their lands with small hand pumps, which they bought by themselves for their own use, and pump water directly from the channels, instead using existing field ditches. This way of irrigation detoured from pump stations, and field ditches, making these irrigation infrastructures deserted.

2. Situation after the project being introduced

Between 2009 and 2010, the farmlands consolidation project entered into the Upper Horse Village. Similarly, the project in UVIS followed the procedure that engineers from the local irrigation planning research center designed the whole construction outline, and outside contractors in charge of construction work. However, local villagers of UVIS were not involved in the design and monitor procedures. With the separation of resource users and infrastructure providers, the project although invested a lot of money (almost seven million yuan, similar to case in BVIS), the outcomes are not satisfactory. According to the interview notes, most respondents told me that those lined canals have serious seepage problems. This makes situations worse off, because when canals were unlined, farmers still can implement some simple repair and maintenance works; when canals were lined with concrete, and seeped seriously, they cannot fix the problem easily. Moreover, some areas really need to be irrigated were overlooked in the project. Pump stations were renovated in the farmlands consolidation project. Still, farmers do not use them in their water allocation.

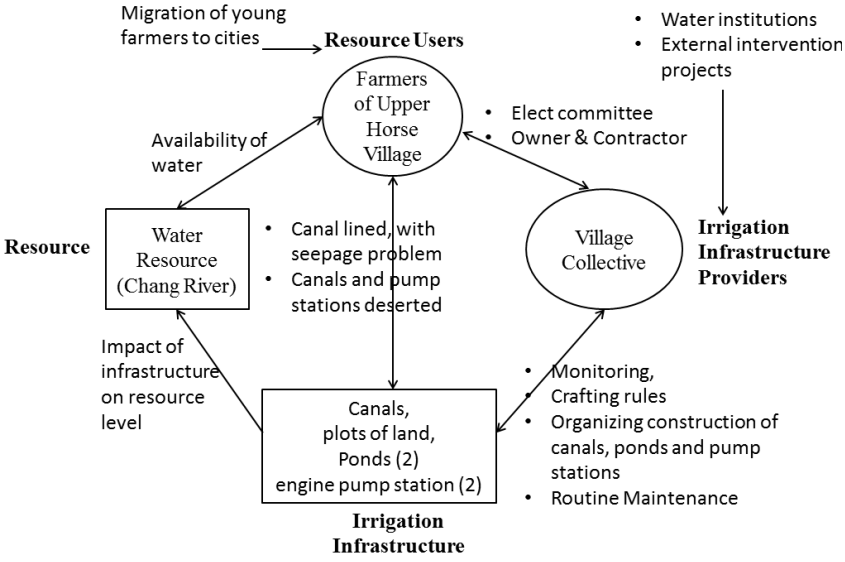

Figure 6: Application of the framework to the current situation of UVIS after the project being introduced.

CONCLUSIONS

In the case of BVIS, based on design efforts from both the farmers and engineers, there are improvements of local irrigation system. Firstly, lined canals cross all fields in the village, to a large extent reduce the water seepage problems; also the

maintenance tasks have largely been reduced[15]; Secondly, elaborate field arrangement guaranteed a low level of deprivation over water allocation among farmers. Thirdly, innovative operation of intake ditches solved the conflicts between up and down fields. Compared to this, the farmlands consolidation project of UVIS was a simple top-down intervention project. Farmers of UVIS received the investment passively and unconcernedly. They have no interactions with irrigation infrastructural providers, which resulted in a flawed project design and problematic constructions.

In both systems, external project entered into local irrigation communities. In the first case, collective choice rights above project were left both in the hands of resource users and infrastructure providers; while in the latter case, infrastructure providers independently make all decisions for local irrigation communities. Although the two irrigation systems are robust temporarily, I can conclude that the adaptive capacity of the irrigation system of Village Bao is higher. Compared to this, if irrigation institutions of Upper Horse Village do not change, the deteriorating situation of local irrigation system cannot be turned around.

Inspired by both cases at hand, there are a few lessons can be drawn upon:

1) When external intervention projects were introduced, it is the best for public infrastructural providers to negotiate with local resource users, to get to know their practical needs, local customs and existing physical situations. Local knowledge is vital for project success.

2) We may not simply require governments to do all the things, even they are project organizers. The truth is they cannot think up a perfect approach by themselves; always flawed, instead. Alternatively, it is possible that local resource users may initiate some good ideas, that really matching up with their own needs. This requires local resource users actively engage in institutional design process.

3) In the settings of rural China, collective activities at present are on a dramatic decrease, because of a series of economic reforms from 1978 to 2004. Individual interests are emphasized. Relatively, village communities have been disorganized since the dismantling of the commune system. Still, there is a chance that these village communities just hibernated, like the case of BVIS. Given necessary incentives (like the introduction of the farmlands consolidation project), they can be reactivated and organize collective action among resource users.

As space is limited, this article is just the start of research about robustness of SES in China. A key issue presented here is that interactions between water users and irrigation infrastructure providers, through their links with water resources and engineering infrastructures, is important for robustness of local irrigation systems. Water users' engagement in institutional design may make a sustainable, robust and adaptive SES.

[15] Earlier unlined canals need villagers clean twice a year, now lined canals just need to be cleaned every two year.

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